XXI.

ON A METHOD OF DETERMINING THE INDEX ERROR OF A MERIDIAN CIRCLE, AT ANY INSTANT, DEPENDING UPON THE OBSERVED POLAR DISTANCE OF POLARIS.

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The three methods which are commonly employed in the determination of the index error of a meridian circle are the following : —

(*a.*) The reading of the circle for the nadir point determined by the coincidence of the real and the reflected images of the central thread of the transit-reticule formed by reflection from the surface of mercury. This reading, which is a function of the latitude, will give the index error under the name of the "zenith-point correction."

(*b.*) The mean of the observed zenith distances of fundamental stars situated symmetrically with respect to the zenith, when compared with the corresponding tabular zenith distances, will yield the zenith-point correction independent of the refraction of the stars observed, since,

For stars south of the zenith, $z = (\phi - \delta) -$ Refraction,

and

For stars north of the zenith, $z = -(\phi - \delta) +$ Refraction.

(*c.*) A comparison of the observed with the tabular polar distances of fundamental stars symmetrically distributed in declination from the pole to a point as far south as the refraction can be securely determined, will give the index error under the form of a polar-point correction. The index error determined in this way, however, involves the systematic errors in declination of the fundamental system through which the observations are reduced. On the other hand, if the fundamental system is really free from this class of errors, this method furnishes the data for an approximate determination of the periodic errors of the circle.

At Washington, and at most other first-class observatories, the first method is employed. At Greenwich, both the first and the second methods are in use, the value adopted for any day being the mean result given by the two methods. At Harvard College Observatory, the third method is employed in all differential observations.

Each method has its advantages, and also its disadvantages. In the use of the first method, either the latitude must be considered as known, or else it must enter as an unknown quantity into the equations of condition formed from the observations. Easy reference to a fixed point would seem to be about the only advantage that can be claimed for this method. Except for this there would seem to be no good reason why we should measure a quantity which is not the quantity sought. Polar distance is the co-ordinate to be directly measured, and the polar-point correction is the correction needed. This can be obtained by observing the polar distance of the Pole-star at both the upper and lower culminations. This method has been exclusively followed for the past five years in the series of observations undertaken by the writer, for the determination of the absolute co-ordinates of about one hundred stars between the first and fourth magnitudes. The defect of this method consists in the requirement that the index error of the circle must remain constant between two adjacent culminations.

It is proposed to verify the constancy of this quantity in the following way.

It has been found that the reversible level invented by Mr. John Clark of the United States Coast Survey serves in the most admirable way to define a fixed reference plane. The reading of the microscopes of the Harvard College Meridian Circle for the indicated zero of the level, which is attached to the cube of the telescope, has now been continued without interruption for nearly two years. A provisional discussion of the results shows that the reference plane thus indicated remains nearly invariable, — certainly it is more steady than the position of the mean of the microscopes upon the circular frame upon which they are mounted with respect to the position of the circle itself.

It is proposed to mount a level of this form upon a horizontal table attached to an arm having an angle with the axis of the earth nearly equal to the polar distance of Polaris when the telescope is set at this polar distance. If the lower end of this arm is mounted upon centres, and if there is attached to the upper end a micrometer screw which is tangent to the arc of revolution, it is obvious that, when the reading of the screw for either culmination of Polaris is known, we can measure

the deviation of the optical axis of the telescope from this plane by reading the circle, the level, and the index of the micrometer screw. In this way a constant watch may be kept upon the position of the microscopes with respect to the circle. The whole apparatus may be conveniently attached to the cube of the telescope. The steadiness of both the level and the microscopes may be inferred from the following readings of the circle for the zero line of the level. They involve the accidental errors of reading both of the microscopes and of the level, as well as actual changes in the position of the mean of the four microscopes. That part of the change which is due to the latter cause will be determined when the observations of Polaris are reduced. Only the seconds of arc are given.

Date.	Circle Reading.	Date.	Circle Reading.	Date.	Circle Reading.
1883.		1883.		1883.	
Feb. 7	57.3″	March 7	57.6″	March 28	57.3″
11	58.8	8	55.7	28	57.5
13	59.8	11	57.4	29	58.5
18	58.7	12	56.5	29	59.8
19	58.3	13	57.5	30	59.3
23	54.9	15	57.6	April 1	60.3
23	56.4	15	59.4	2	56.6
25	55.9	21	57.9	3	57.0
27	58.6	22	57.4	6	57.4
March 2	56.8	24	59.2		
2	57.4	26	60.1		